REPORT TO CONGRESS
ON
THE CAPABILITIES OF THE SDI NATIONAL TEST BED

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Prepared by the

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CONTENTS

ACRONYMNS

ABM	Antiballistic Missile
BM/C3	Battle Management/Command, Control and Communications
DETEC	Defense Technology Evaluation Code
ESD	Electronic Systems Division
FSED	Full Scale Engineering Development
LAN	Local Area Network
MEM	Mission Effectiveness Model
NTB	National Test Bed
NTBJPO	NTB Joint Program Office
NTF	National Test Facility
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
SDS	Strategic Defense System
SOW	Statement of Work
TEMP	Test and Evaluation Master Plan
TRD	Technical Requirements Document
TW/AA	Tactical Warning and Attack Assessment

SECTION 1
INTRODUCTION

A. PURPOSE OF REPORT

This report has been prepared for the Committees on Appropriations of the United States Senate and House of Representatives pursuant to the requirements of Section 125 of the fiscal year 1988 Military Construction Appropriations Act, HJ Resolution 395, P.L. 100-202.

In the January 1985 publication, "The President's Strategic Defense Initiative," the President stated:

> The Strategic Defense Initiative (SDI) is a program of vigorous research focused on advanced defensive technologies with the aim of finding ways to provide a better basis for deterring aggression, strengthening stability, and increasing the security of the United States and our allies. The SDI research program will provide to a future President and future Congress the technical knowledge required to support a decision on whether or not to develop and later deploy advanced defensive systems.

The criteria which the President has set forth for a Strategic Defense System (SDS) are military effectiveness, survivability, and cost-effectiveness.

If deployed, SDS will be more complex than any other system the world has seen. Its military effectiveness and survivability can never be completely and fully tested as a whole, short of the actual conditions of full scale conflict. Thus, the National Test Bed Program was created. The NTB will be the pivotal research and development tool providing the capability to develop and evaluate SDS architectures, human interface elements, and component technologies. The NTB will evolve in increments which directly link and support SDS integration and will eventually represent the SDS in sufficient fidelity to contribute significantly to the process of evaluating SDS for military effectiveness, survivability, and cost effectiveness without actually building or deploying SDS.

The NTB is, of course, not the sole element of the SDI program needed to demonstrate that the strategic defenses of SDS meet the President's criteria. It is best visualized as one of many tools for SDS research, development, test and evaluation which will occur at many levels. The NTB is the principle tool that will be developed and used to represent the SDS in whatever detail is necessary and possible to support many levels of evaluation and system integration.

B. NATIONAL TEST BED (NTB) PROGRAM DESCRIPTION

The NTB program will compare, evaluate, and test alternative architecture definitions for an end-to-end layered strategic defense and its associated battle management/command, control, and communications (BM/C3). NTB will also evaluate specific technology applications in a system framework defined by these architecture alternatives. The NTB will consist of a network of geographically separated experiment and simulation facilities that will be electronically linked to simulate a layered ballistic missile defense system. At the center of this network will be the National Test Facility (NTF), which will serve as the central control and coordinating point for the NTB. The NTF will also be the major simulation activity for the SDI Program, and will develop and execute large-scale distributed simulations of the SDS. It will provide as much realism as possible within the constraints of international agreements and funding. As an integrated set of resources, the NTB will be a single national resource dedicated to the SDI for addressing the many critical issues necessary to support an informed decision on future, full-scale development and deployment of strategic defense against ballistic missiles. Other SDI efforts which will contribute to such an informed decision include the development of a technology base to support initial development and reactions to Soviet responses, as well as technology validation, consisting of many experiments that determine readiness to proceed with full-scale development.

The NTB will comply with the ABM Treaty (Ref. 5). Except for selected and time limited experiments, the NTB will not be electronically connected with the operational battle management or command and control segments of any element of the National Command Authority network for Tactical Warning/Attack Assessment (TW/AA). Since the NTF supports a long-term research mission, it will be constructed with a reconfigurable interior design and will be a simulation facility. It will not be allowed to assume the fixed operational configuration and sensor connectivity required for a command center for a future Strategic Defense System. Additionally, the NTF's above ground vulnerability make it unsuitable as an operational command center.

The participation by the NTF in actual SDI experiments will be reviewed on an ongoing basis by the DoD Treaty Compliance Group which is independent of the SDIO.

SECTION II
REQUIREMENTS, GOALS AND ACQUISITION STRATEGY

A. SDS REQUIREMENTS: THE PRESIDENT's CRITERIA

A strategic defense system that would devalue offensive ballistic missiles to a meaningful degree and, therefore, meet the long term goal of the Strategic Defense Initiative Program, will have to meet the same three specific standards that apply to other military systems.

The first requirement is military effectiveness. A defense against ballistic missiles must be able to destroy a sufficient portion of an aggressor's attacking force to deny him confidence that he can achieve his objectives. In doing so, the defense should have the potential to deny that aggressor the ability to destroy a militarily significant portion of the target base he wishes to attack. Furthermore, if a deployed defensive system is to have lasting value, technology and tactics must be available that would allow the system to evolve over an extended period to counter plausible responsive threats. Such a robust defense should have the effect of deterring a strong offensive response and enhancing stability. This report is based on the understanding that the requirements of technical feasibility mentioned in the Congressional reporting requirement are the same as those of the President's criterion of military effectiveness.

The second requirement is adequate survivability. Defenses must maintain a sufficient degree of effectiveness to fulfill their mission, even in the face of determined attacks on the defenses, including the possible loss of some individual components. Such a capability will maintain stability by discouraging such attacks. Survivability means that the defensive system must not be an appealing target for defense suppression attacks. The adversary must be forced to pay a penalty if it attempts to negate the defense. This penalty should be sufficiently high in cost and/or uncertainty in achieving the required outcome that such an attack would not be seriously contemplated. In the context of a future SDS, survivability would be provided not only by specific technical capabilities such as employing maneuver, ASAT sensor blinding, and protective shielding materials, but also by using such strategy and tactical measures as proliferation, deception, and self defense. System survivability does not mean that each and every element of the system need survive under all sets of circumstances; rather the defensive force as a whole must be able to achieve its mission, despite degradation in the capability of some of its components.

The third requirement is that options generated by research be evaluated to the degree that the defensive systems discourage an adversary to overwhelm them with additional offensive

capability. The SDI research program seeks defensive options--as with other military systems--that are able to maintain their defense capabilities more easily than countermeasures could be taken to try to defeat them. This criterion is expressed in terms of cost-effectiveness at the margin; however, it is much more than an economic concept.

B. NTB REQUIREMENTS, GOALS AND ACQUISITION STRATEGY

These overall SDS requirements determine the goals and capability for the National Test Bed (NTB). The NTB will provide the means (see Section III) for system-level simulation, evaluation, and demonstration. Models of SDS elements will be hosted on computers located in the NTB. These models, together with simulated threat, operational environment, engagement, and economic models will provide data to determine the military effectiveness, survivability, and cost-effectiveness of a future SDS. To meet these objectives, the SDIO has established several goals for the National Test Bed Program. These are:

- To establish a distributed National Test Bed consisting of currently existing and planned analytical and hardware test facilities which will provide a set of standard SDS simulation drivers and evaluation tools. These drivers will include a family of simulations for the representation of the threat environment (both natural and man-made).

- To establish the National Test Facility as the central element for the integration and operation of the National Test Bed. The NTF will be primarily a computer based simulation facility. It will also provide communications to allow the NTF to operate with other computer based or hardware-in-the-loop simulation or test facilities, as well as National Test Range assets. This integrated test and simulation capability of the NTB will provide additional confidence to simulation results than would be possible with solely computer based simulations.

- The NTB program will provide a simulation environment for the conduct of end-to-end systems simulations to support architectural analysis of the Phase I and follow-on architectures, with specific capabilities to provide detailed data on system functions and interactions.

- The NTB will support simulations and technology experiments through the collection and analysis of data.

- The NTB program will provide an experimental environment for BM/C3 by developing an end-to-end simulation capability of sufficient scope and fidelity to drive the test and evaluation of candidate BM/C3 hardware and software. This will permit the execution of candidate battle management software on commercial computers as well as newly developed hardware. It will permit the execution of man-in-the-loop simulations for the development and validation of operational concepts.

- The NTB program will provide an evolving end-to-end system emulation for the validation of system integration issues and evaluation of end-to-end system effectiveness and survivability. This capability will evolve over time to be the most accurate representation of a future SDS that can be produced without producing the actual system.

- The NTB program will provide an extensive computing resource for the conduct of special studies as required.

- The NTB will support an informed Full Scale Engineering Development Decision (FSED) for an operational SDS.

- The NTB will, with additional development to be funded by the appropriate programs, be a national capability to simulate defense research other than the SDI.

The goals are consistent with the mission of the National Test Bed Joint Program Office (NTBJPO), as defined by its organizational charter (Ref. 2).

> In coordination with the Services and other users, the NTBJPO shall define, design, acquire, integrate, operate, maintain, and improve a SDI comprehensive capability to experiment with and evaluate alternative SDI system and battle management/command, control and communications (BM/C3) architectures and key defensive technologies in support of the SDI technology verification strategy. (Ref. 1).

In addition, the NTBJPO will propose and participate in the design and integration of experiments.

The requirement for SDS elements to undergo NTB system-level testing are broadly stated in the SDI Test and Evaluation Master Plan (TEMP). Specific schedules are being developed to support this requirement. (Ref. 6).

The acquisition strategy for the NTB has been based upon a three phase, competition intensive approach. Phase I, conducted in March-June 1986, involved four prime contractors and their subcontractors. Phase I resulted in defining the concept for the NTB. Phase II, conducted July-December 1986, involved two prime contractors (competitively selected from the original four) and resulted in the preparation of the preliminary design for the NTB. Phase III will be awarded competitively to a single prime contractor in January 1988, and will include the final design, the implementation, and the operation of the NTB as discussed throughout this report.

SECTION III

NTB CAPABILITIES

The Government has written a Technical Requirements Document (TRD) (Ref. 3) and a Statement of Work (SOW) (Ref. 4) which specify required NTB capabilities. The source selection is in progress to select the contractor to provide the NTB simulation, evaluation, and demonstration capability. Contract award is scheduled for January 1988.

The NTB effort parallels and supports the evolution of the SDS architectures. The NTB will be flexible enough to adjust to differing architectures.

NTB capabilities will produce the simulation, demonstration, and evaluation data decision makers will require. The following is a summary of the detailed capabilities which will result from the NTB integration contract:

A. SIMULATION

In order to choose an appropriate and adequate baseline simulation framework, the NTB will host and evaluate several end-to-end simulations. The following are candidate end-to-end SDS simulation models which are currently in development. The Mission Effectiveness Model (MEM), developed by Vanguard Research; Defensive Technology Evaluation Code (DETEC), developed by Los Alamos National Laboratory; and Blue Defender, developed by ANSER Corporation. The Government will review the contractor recommendations for the end-to-end simulation framework, and provide guidance on SDI and NTB mission requirements. Early selection of the baseline simulation framework is important, since developers of other SDS elements must have a specified interface to design against in order to bring their simulations into the NTB for system-level testing. As each developer produces a successful simulation version of that SDS element, it will reside in the National Test Facility where it will be validated against experimental data, certified for use by other developers, and executed within the context of end-to-end system simulation. Developers will be responsible for evolving their models in the direction of increasing fidelity. Eventually, the NTB end-to-end simulation will consist of high fidelity versions of all elements, and thus will closely emulate the SDS system. Each step of this process reduces the risk in developing and fielding SDS elements. The NTB will also have solved some of the integration issues before they can affect the SDS itself.

The NTB contractor will be required to prototype a distributed simulation framework which includes: time-synchronization for components located at remote locations; provisions for hardware-in-the loop evaluations; man-in-the-loop evaluations; and geographically distributed access for participating facilities.

B. COMMUNICATIONS

The NTB integrating contractor will provide internal and external communications capabilities. Internal communications include both voice and data communications over multiple Local Area Networks (LANs). Performance requirements, protocols, timing, and security requirements are all specified. External communications also include voice and data communications. Dedicated support communications are specified between the NTF at Falcon AFS, CO; the SDIO in Washington, DC; the Army Strategic Defense Command (SDC) in Huntsville, AL; the Air Force Electronic Systems Division (ESD) at Hanscom AFB, MA; the Air Force Space Division (SD) at Los Angeles AFS, CA: the Naval Research Laboratory (NRL) in Washington, DC; the Department of Energy Los Alamos National Laboratory (LANL) in Los Alamos, NM; the Air Force Rome Air Development Center (RADC) at Griffiss AFB, NY; and Air Force Space Technology Center (AFSTC) in Albuquerque, NM. These data links will provide access to the simulation and analysis capabilities of the NTB for the participating organizations listed. As the distributed simulation prototype and interfaces are developed, these nodes will be able to run their simulations in a distributed manner. For example, SDC will run its BM/C3 experimental version at Huntsville while connected to the threat model, sensor model, weapon model, and engagement environment executing at the NTF. Additional nodes will be added as new contractors, developers, ranges, laboratories, and participating agencies become involved.
These communications requirements are specified in Reference 3.

C. PROTOTYPES

While the simulation framework is perhaps the most important prototyping effort, the NTB integrating contractor will be responsible for others. For example, the experiment control center in the NTF will consist of workstations, large screen displays, and the capability to interconnect with other nodes of the NTB. Another effort will be the interactive gaming center, also with workstations and displays. This center will include areas for a "Blue" team, a "Red" team, and a "White" team to accommodate gaming "what if" scenarios, and experiments involving man-in-the-loop and human factors. Scenario and simulation object generation capabilities will also be

prototyped to provide highly sophisticated threat and environment models. These and other prototyping efforts are specified in Reference 3.

D. DECISION SUPPORT

An extensive technical information support capability will reside in the NTF for storage and retrieval of documents, software, experiment data, simulation models, and other SDI information. This will provide access for researchers and national decision-makers to documented experiments, simulations, analyses, and other information to enable them to make decisions on further SDI developments, trade-offs, and funding. This requirement is specified in Reference 3.

E. BM/C3 SUPPORT

BM/C3 Experimental Versions (EVs) will be hosted in the NTF. These EVs, under development by ESD at Hanscom AFB and SDC at Huntsville, will be tested with other SDS elements. As they mature, each successive version will form a central core of the NTB system-level architecture. These requirements are specified in Reference 3.

F. NTB INFRASTRUCTURE

The NTF will also host tools for administrative and engineering support for the NTB. Included under these requirements are: project management; resource planning; logistics; security administration; document production; hardware/software engineering; configuration management; engineering analysis; simulation/experiment planning, execution, and analysis; and data reduction. Included among these will be automated tools for such uses as resource planning and NTB configuration management. These requirements are specified in Reference 3.

G. HARDWARE

NTB requirements do not specify brand names of hardware. The requirements include numbers in some cases, such as number of large-screen displays in the experiment control center, but most of the hardware types and quantities will be proposed by the contractor based on known mission requirements, dimensional characteristics, physical characteristics, environmental conditions, security requirements, reliability/maintainability/availability requirements, and minimum performance requirements. Early milestones (six month to two years) specify at least one supercomputer and a robust complement of mainframes, workstations, and peripheral

hardware. Hardware will be added as the SDS architecture and the NTB prototypes both mature. These requirements are specified in Reference 3.

H. SOFTWARE

The NTB integrating contractor will host end-to-end simulations in the NTF, as mentioned above, and will be responsible for some software prototyping. Use of Ada will be required for new code. A software engineering environment will be installed which includes software development, maintenance, and integration tools, and performance analysis software. These requirements are specified in Reference 3.

SECTION IV

EVALUATION APPROACH

The SDI will use the simulation, demonstration, and evaluation data produced in the NTB to answer the feasibility, cost-effectiveness, and survivability issues addressed in Section II.

A. TECHNICAL FEASIBILITY AND MILITARY EFFECTIVENESS

The NTB will be the only national resource to combine all the SDS elements into a system-level framework to measure performance through simulation. An individual element such as Battle Management/Command, Control, and Communications (BM/C3) will have to demonstrate time lines to coordinate sensor information with targeting, weapons release, and kill assessment. Actual NTB models of these elements will evaluate these time lines and determine how effectively they perform and where fixes are required.

This system-level capability will continue to evolve for all SDI phases and will contribute to decisions of feasibility and military effectiveness for each technology/element. For example, the simulation might demonstrate that a new weapon technology would significantly increase cost without adding much to performance. That technology could then be reworked or scrubbed in favor of a more cost-saving approach.

As these individual element models are refined, they will be integrated with the SDS architecture to conduct system performance evaluations. Multiple distributed simulations of the SDS will provide such parameters as kill ratios at boost, post-boost, midcourse and terminal phases of the attack; leakage rate of attacking warheads (i.e., how many survived each layer of the defense); and optimum mixes of defending assets. At this level, the NTB will be simulating, evaluating and demonstrating the overall SDS performance and military effectiveness.

These results will provide national decision-makers with information crucial to decisions on full-scale development and deployment of strategic defenses.

B. SURVIVABILITY

The NTB will provide trade-off analyses on survivability and related topics as well (reliability, maintainability, supportability, system availability, and logistics, for example). One

example of a survivability analysis is hardness vs number of platforms. Both are measures of survivability, but hardness increases weight and decreases the number of platforms that can be launched. Using NTB models, analysts can simulate numerous combinations of the two factors to determine an optimum mix. Other factors which bear on the survivability of individual elements include: maneuver, velocity, self-defense, concealment, failure nodes, and tactics. Survivability of assets, both offensive and defensive, will be built into the models to determine sufficient deployment options to deter an attack or to withstand a potential attack.

Supportability models will permit trades involving the quantity and nature of on-orbit and ground operations required to service, maintain and operate a specified architecture.

C. COST EFFECTIVENESS

Cost-effectiveness states that, to be effective, a defensive system would have to provide disincentives or strategic leverage against the Soviet Union responding to defenses by deploying countermeasures and/or proliferating ballistic missiles. The form these disincentives could take are economic, technical, and military.

Defenses with strategic leverage would stress the limits of Soviet technical capability in such a way as to discourage the Soviets from believing that a U.S. defense system could be overcome at any price. To achieve this, prospective defensive technologies must be able to demonstrate the likelihood of being able to counter effectively any technologies, offensive force growth, or changes in strategy that might be employed to reestablish the capabilities of ballistic missile forces.

Finally, the defense also must be able to impose serious opportunity costs on the Soviets, such that any effort to counter the defense through countermeasures and/or proliferation of ballistic missiles would be so costly as to impose severe limits on the resources it could bring to bear on other Soviet priorities, such as alternative offensive forces that are less destabilizing, defensive efforts (both active and passive), conventional forces, and efforts to improve their economy as a whole.

The NTB will provide the capability to do multiple simulation iterations of a wide range of possible offensive and defensive strategies, countermeasures, economic impacts, and varying degrees of technical capability. Policy-makers will then be able to formulate appropriate and

informed policy with confidence that the economic, technical, and military elements of cost effectiveness are understood.

REFERENCES

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3. Statement of Work for the National Test Bed Integration Contract, Electronic Systems Divison, Air Force Systems Command, Hanscom AFB MA, 28 July 1987.

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5. Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems, signed by the President of the United States and the General Secretary of the Central Committee of the CPSU, 26 May 1972 (Entered into force 3 October 1972).

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